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REGIONAL AGRICULTURAL RESEARCH

A Quarter Century of Achievement Through Cooperative Endeavor 1947-1972

Cooperative State Research Service
U.S. DEPARTMENT OF AGRICULTURE
In Cooperation with the
State Agricultural Experiment Stations

Miscellaneous Publication No. 1273

Historic, archived document

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May 1973

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FOREWORD

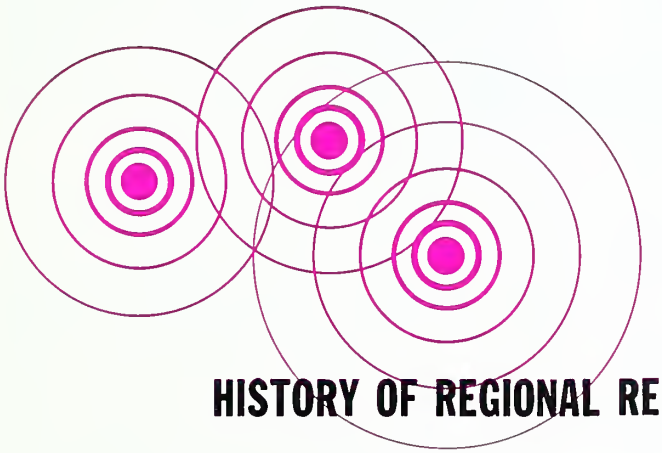
The record of achievements in agricultural research in the United States is one of the miracles of this century. This enviable record has resulted in part from a unique plan of cooperative Federal-State endeavor known as the Regional Research Fund (RRF) program.

This publication highlights some of the achievements that have marked the progress of the RRF program since it began in 1947. It is an exciting saga of man using the tools and methods of science to solve agricultural problems through the cooperative effort of two or more States and United States Department of Agriculture research agencies.

Team effort helps speed the solution of problems and application of results. Moreover, RRF projects have led to more efficient use of State-Federal research resources and manpower.

The Committee of Nine hopes this 25th anniversary publication will foster a wider appreciation and understanding of what regional research has meant to the overall agricultural research program in the United States. At best, it reviews only a small sampling of the total effort. Readers may obtain more information by writing to the particular State agricultural experiment stations involved or to the Cooperative State Research Service, U.S. Department of Agriculture.

C.P. Wilson, Director
Hawaii Agricultural Experiment Station
Chairman, Committee of Nine



HISTORY OF REGIONAL RESEARCH FUND

The concept of regional agricultural research in the United States dates back before the turn of the century. Research leaders and workers saw the need for cooperative action on problems of common concern. But the extent of their joint effort was hindered for many years by restrictions on interstate travel and limited funds for research. Characteristic of the times, scientists also were reluctant to engage in group research.

As continued growth of agriculture brought more demands for research on pressing problems, State experiment stations found that their individual efforts were inadequate to meet the needs. Research workers began, therefore, to organize regional conferences to pool resources and exchange information. In 1913, livestock research workers in the Southern States met to discuss their major problems in livestock production. They talked about what each institution could do and each agreed to tackle one aspect of a common problem. Progress was limited, however, until 1922 when they established a livestock council which helped to get support from the U.S. Department of Agriculture.

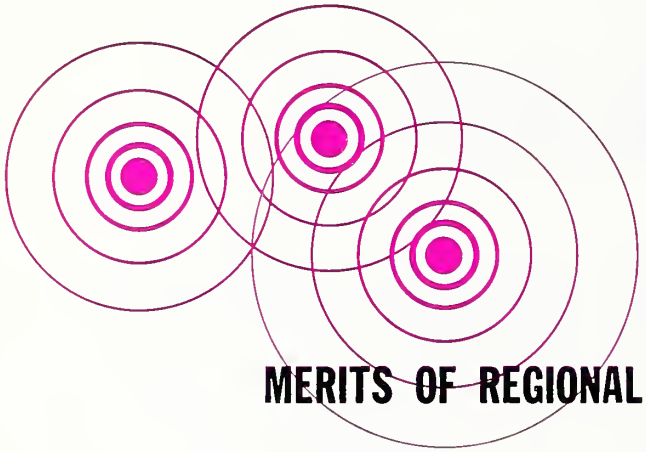
The Purnell Act of 1925 stimulated more cooperative research by increasing the Federal grants available to each State and by broadening the fields of research that stations were authorized to cover. Although this act contained no special provision for regional research, Federal and State research administrators expanded this aspect of their programs by developing projects having regional significance. The experience proved to be useful many years later.

A further boost in cooperative research came with the passage of the Bankhead-Jones Act of 1935 which established regional laboratories and provided additional funds that stimulated cooperative work among the States. Planning groups were set up, each of which was charged with the responsibility for planning a regional project within their respective fields. The unit for teamwork on research became the technical committee, and an administrative adviser provided guidance. An essential requirement for coopera-

tive regional research, however, was still lacking: specific funding to provide a nationwide, stable program.

In the early 1940's, farm and marketing organizations strongly supported regional research. The Experiment Station Committee on Organization and Policy (ESCOP) developed an amendment to the Bankhead-Jones Act of 1946 which provided that 25 percent of the increase in appropriated funds for State experiment station research should be allotted to cooperative research on problems concerning the agriculture of more than one State. These funds are designated the "Regional Research Fund, State Agricultural Experiment Stations," now commonly referred to as RRF. Projects must be recommended by a committee of nine persons elected by and representing directors of the State agricultural experiment stations, and approved by the Secretary of Agriculture. The Act further provides that travel expenses of the committee in performance of their duties shall be paid from these funds.

The RRF was activated in 1947 at a level of $625,000 in support of 25 regional projects. Each year the program has expanded to a current level of nearly $15 million and about 170 projects. Additional State and Federal funds have increased the total annual support of the program to nearly $40 million in fiscal 1973.



MERITS OF REGIONAL RESEARCH

The planners of RRF research envisioned a number of advantages to the concept of a concerted, cooperative attack on problems common to a region. Their hopes have been well realized.

Regional research resolves by team effort problems too large for a single station or agency to attempt to solve. Because regional research brings together highly competent scientific talent from experiment stations and Federal agencies, both the solutions of problems and the applications of results occur much more quickly than by isolated effort. At the same time, it has helped to avoid the costly duplication of similar research at more than one location.

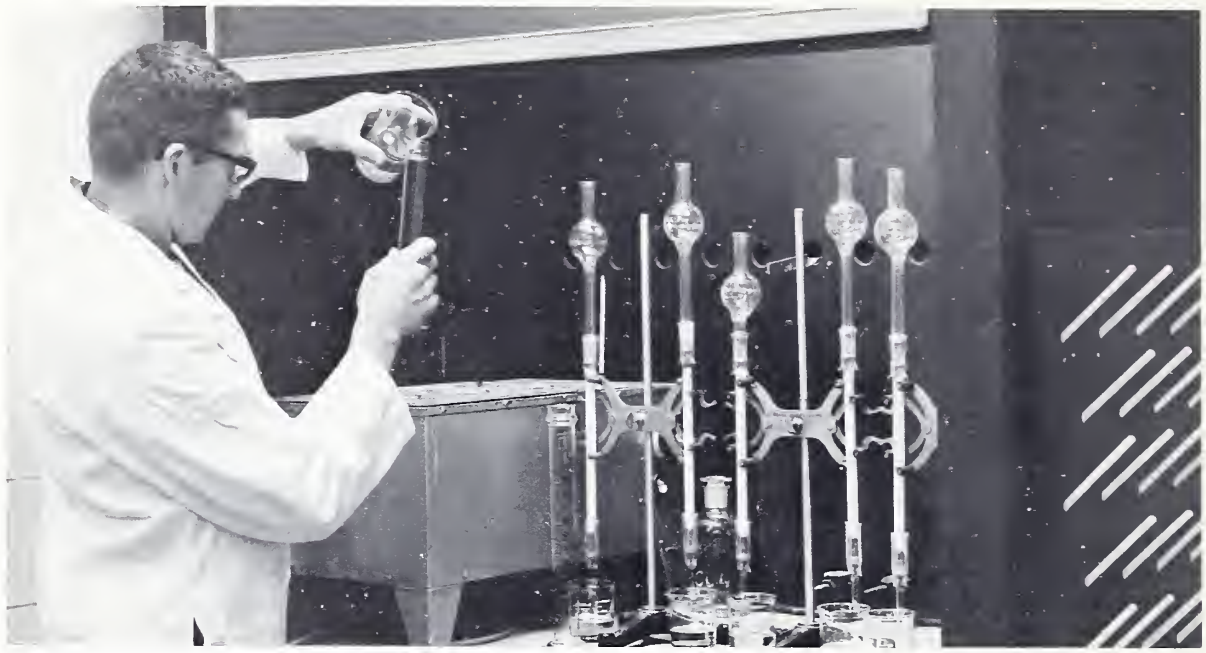
Those who do the actual work on regional projects—the scientists themselves—are quick to point out that their involvement under RRF is a stimulating experience because it brings them in close contact with others having like interests and goals. The mutual exchange of information and ideas invariably pays off.

During the 25-year span of RRF achievements, two unanticipated advantages have added considerably to the merit of the program. Regional projects provide increased opportunity for concentrating research competence and funds on problems at locations where there is a high potential for significant progress. Secondly, the RRF program has an enviable record of stimulating young scientists to become more competent and responsive in their fields.

HOW RRF WORKS

Cooperative regional projects usually develop at the grass roots as proposals and recommendations of scientists to cooperatively attack the problems of agriculture. Next, a regional association of directors appoints an administrative adviser—usually a State experiment director or assistant director—to organize a technical committee made up of one representative from each State participating in the research. The technical committee, in turn, develops a specific plan and assignment of responsibilities. The proposal is reviewed by the Committee of Nine and recommend to the Cooperative State Research Service for approval and funding. Each technical committee meets generally once a year to review progress and plan research.

The regional boundaries of the four associations of experiment station directors were adopted as the administrative and physical regions for the cooperative research programs (see map). In project planning, however, interaction among regions is frequently necessary. A mechanism is provided for interregional research participation when the problem transcends regional boundaries.



REGIONAL RESEARCH GOALS

Regional research helps agriculture fulfill its role in meeting overall national objectives by directing its attention to the following goals:

- Insure a stable and productive agriculture for the future through wise management of natural resources.
- Protect forests, crops, and livestock from insects, diseases, and other hazards.
- Produce an adequate supply of farm and forest products at decreasing real production costs.
- Expand the demand for agricultural products by developing new and improved products and processes and by enhancing product quality.
- Improve efficiency in the marketing system.
- Protect consumer health and improve nutrition and well-being of the American people.
- Assist the 54 million rural Americans to improve their level of living.
- Improve community services and environment.

The payoff, of course, is how well agricultural research under the RRF program has achieved success in trying to meet these goals. The record should speak for itself.

Resource Conservation and Use

Agriculture depends on three vital, basic resources for its existence—soil, water, and air. The RRF projects in this area of research have sought to develop, conserve, and use these resources for the best interests of present and future generations.

Soil

America learned by bitter experience that our soil is a priceless heritage deserving wise management. Since the early 1900's, the movement toward conservation of this resource has been heavily science oriented. Contributions from regional research in this area lie mostly in the basic sciences, particularly those that relate to problems needing the cooperative endeavor.

Soon after the RRF program began, soil and plant scientists in the North Central region tackled the challenging complexity of evaluating soil structure and learning how plants respond to its varied states.

One noteworthy accomplishment was improvement in ways to measure the various facets of soil structure. With modern instrumentation, scientists can now determine the gas and water content of soil right at the site of study. This knowledge is extremely useful for guidance on crop choice and as an indicator of deficiency conditions.

These North Central projects also revealed that (a) subsoil influences plant growth as much as topsoil, and (b) soil compaction reduces nutrient uptake of plants. These studies, in turn, led to improvement of soil management systems and, indirectly, to new designs of tillage implements.

Out of these studies also came a better understanding of the importance of soil organic matter to productivity.

Cooperating States in other regions studied many other aspects of soil physics and soil-plant relationships. Among their findings are:

- Improper aeration can restrict germination and seedling growth by as much as 80 percent.
- Seedling emergence in compacted soils can be improved by shallow planting.
- Guidelines for nitrogen fertilization, an outgrowth of the research, added to knowledge needed to reduce nitrate pollution of the environment.
- Sulphur was shown to be a critical mineral element for crop growth on some soils.

Water

Regional resource research has wrought major influence through a score or more projects dealing with the conservation and use of water. This concentration of research on water has been deliberate because water—or the lack of it—strongly influences the quality of American agriculture.

Since many agricultural water problems stem from shortages in certain regions rather than total national supply, research has concentrated on increased water use efficiency.

One of the earliest projects initiated by Western regional directors focused on the economics of alternative methods of water application—sprinkler *vs.* surface irrigation. Special emphasis was placed on comparing costs of each method for given situations.

Scientists in Utah, Wyoming, and Washington found that sprinkler irrigation requires 30 percent less water per acre than surface irrigation, although terrain and soil type may govern the choice. Additional water was saved by constructing concrete-lined ditches and permanent main lines—an improvement given a boost by Federal assistance.

Ranchers in Nevada were shown how they could improve productivity of mountain meadows by using irrigation, together with proper fertilization and land leveling. Meadow improvement appears to be one of the best opportunities for ranchers to maintain or expand livestock operations.

Under this project, considerable basic research has been done on problems of alkaline and saline soils. Drainage and water control were the key approaches. Agriculturists in Colorado noted that the additional net revenue on farms where these principles were applied more than offset the cost of field drainage systems. Even more important, ground water reserves improved.

Other accomplishments:

- Developed instruments for basic hydrological measurements.
- Improved accuracy of forecasting seasonal water supplies based on snow surveys.
- Discovered that light precipitation, even though it may not enter the soil, is useful because it reduces transpiration losses from plants.

- Developed techniques to measure the effect of crop irrigation on soil moisture status.

A regional study analyzing ground water laws in Western States has revealed some inequities in existing State codes, and, in turn, led to new concepts and practices in groundwater usage.

A related project led to adoption of more equitable legal rules affecting water transfer under heavy demand situations. Dollar values were assigned to irrigation water uses and compared with other alternatives as aids in determining how available water should be allocated for the ultimate good of all citizens.

Typical of regional research in other areas of the country is a Northeast project on soil-plant-water relationships as a basis for irrigation. Highlights of this 7-year project are:

- Recommended irrigation limits for tobacco plants to hold down incidence of weather fleck disease in the Connecticut River valley.
- Contributed to knowledge leading to increased efficiency of design of irrigation pipe couplers.
- Supplied data showing benefits from increasing plant populations of most irrigated vegetable crops.
- Published a bulletin giving growers guidelines on irrigating all Northeast crops. The benefits: Greater water conservation and, in many cases, higher profits by using crop varieties more amenable to irrigation.

Weather

Although research on climatology seems unrelated to resource conservation and use, nothing is more important to a farmer's business than the weather.

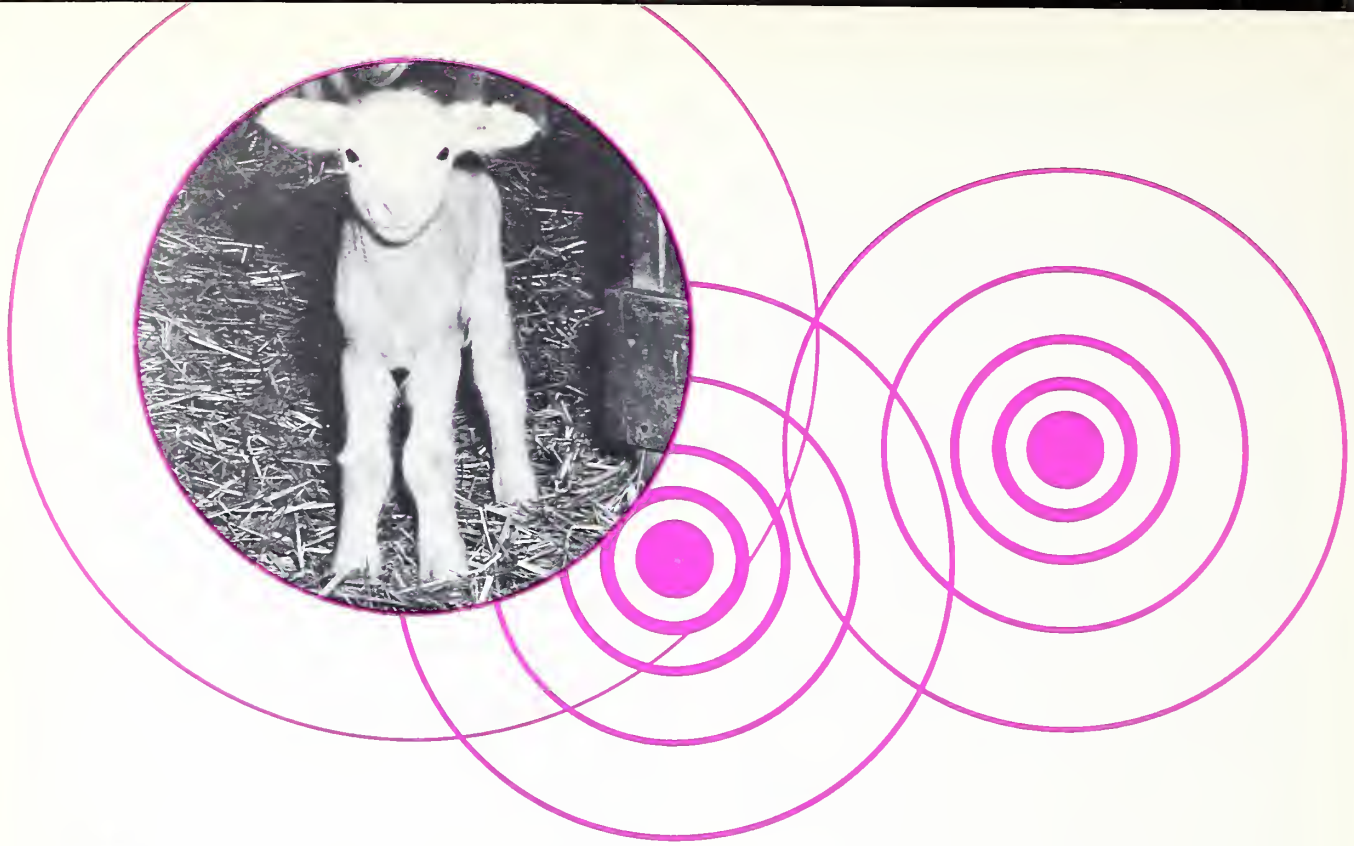
From a scientist's viewpoint, agricultural climatology is one of the most challenging subjects for research. Because of the vast scope of the field, significant progress would be impossible without cooperative State and Federal effort and the close working relationships of many disciplines: meteorology, hydrology, plant psysiology, soil science, and agricultural engineering.

Climatology became a part of the RRF program in 1956 under a Northeastern project seeking to (a) develop new ideas and ways to analyze and apply climatology in agriculture, (b) investigate how climatic variables are related to plant growth and development, and (c) set up a network for phenological observations to study plant response to the environment. Liaison was developed with counterpart regional groups in the North Central and Western States working on similar projects. An interchange of ideas and methods on an interregional basis has strengthened the effort in every region.

One of the first steps was to compile daily weather observations on punched cards—later, on magnetic tape. These data, together with historical weather records, were used to improve the accuracy of estimates of risk from climatic factors, such as delineating early and late crop areas for specific plants. Sub-projects and data from the phenological network yielded new and useful information about plant-climate relationships.

Notable contributions were made in a wide panorama of weather-related activities and situations—all of which have been documented and published during a fruitful 15-year period of outstanding research achievement and user service.

- Data on drought and weekly precipitation probability now provide a much-needed way to evaluate effects of dry weather on general crop conditions, forest fire danger, water supply, and economic consequences of abnormal weather.
- The principle of growing-degree days—a profile crop response to daily temperature changes—is now used to predict growth rates and maturing dates for crops.
- Evapotranspiration studies and their findings can now be used to assess the need for investment in irrigation equipment and to schedule the time and determine amounts of water to be applied.
- Snowfall and snow depth probabilities have provided a basis for allocating time, funds, and equipment for snow removal in both rural and urban areas.
- The National Weather Service, in its agricultural weather program, is now using information from these RRF studies to issue forecasts and warnings that allow farmers to carry out timely spraying programs, protect crops against extreme weather events, schedule irrigation, and plan other weather-related farming operations.



Protecting Crops and Livestock

No one knows for sure the magnitude of agricultural losses caused by insects, diseases, and weeds in the United States. Even conservatively estimated, these losses may well run over $1 billion a year. For insects alone, a 1963 USDA estimate stated that the ravages of these pests nullified the productive efforts of 10 percent of the farm labor force.

Losses are of two types: (1) the actual food and fiber damaged or destroyed, and (2) the monetary and manpower costs required to keep these losses from becoming greater than they already are.

Alarming though these losses may be, they do not begin to compare with those in countries where crops and livestock receive less protection. In some areas of South America, for example, crop losses alone may run as high as 40 percent. The United Nations reports that 55 million Africans could be fed for a year from the grain finding its way to the wrong consumers—rats, locusts, quelea birds, beetles, moths and weevils, and countless micro-organisms.

The extra protection U.S. products receive brings economic benefits that more than justify both the research investment and the costs of applying the technology. An illustration from research in the North Central region bears this out. Corn hybrids being used in 1965 were about 10 percent more resistant to corn borers than those used in 1955. In one State alone—Minnesota—this resistance factor brought annual savings of $300,000 to growers.

Crops

Since the 1960's, research under the RRF program has concentrated more and more on crop pest control methods that emphasize insect-resistant varieties, crop management techniques, and biological control.

For such research to yield fruitful results, it is generally necessary to study the bionomics of the target insect, that is, an orderly study of its habits and life patterns. The fight against the cereal leaf beetle is a prime example of how such efforts pay off.

The cereal leaf beetle, a native of Europe, was discovered in Michigan in 1962 and soon proved to be a potentially serious threat to the cereal grain industry in the Midwest because of

its rapid spread and voracious appetite. If the beetle is not controlled, losses in spring grains can run as high as 75 percent.

North Central experiment station directors, recognizing the need for immediate action, initiated a regional project in 1963 which concentrated on populaton bionomics and an intense program of integrated control. By the time the project was closed out in 1968, scientists had the knowledge they needed to keep the beetle from becoming economically devastating. These studies led to the development of safe and intelligent chemical control measures in the protection of oats. Research on host plant resistance and biological control holds much promise for less emphasis on chemical control.

After the regional project ended, research continued in the affected States—much of which is concentrated in Michigan where practically all the Lower Peninsula is infested. Because the research is carried on mainly at the Michigan State University Pesticide Research Center which RRF originally helped to build and equip, RRF continues to make an effective contribution. Present research heavily emphasizes two kinds of biological control—egg and larvae parasites and resistant plants.

The queen of the battle is a tiny wasp—about the size of a fruit fly—imported from France and Yugoslavia. Through the help of Cooperative Extension agents, the wasp has been released in most Lower Peninsula counties, where it is expected to play a big role in beetle control efforts.

In the area of plant resistance, cooperative research in Michigan has led to the development of a wheat variety having greater than normal amounts of leaf hairs. The hairy wheat makes it difficult for the adult beetle to lay eggs and acts as a barrier to larval feeding.

A serious outbreak of a virus disease of corn in Ohio in 1963 prompted North Central experiment station directors to recommend a regional project to cope with the problem. The disease was first thought to be corn stunt, but was subsequently found to be caused by a new virus—now referred to as maize dwarf mosaic virus (MDMV).

There is no known cure for MDMV. Research, therefore, was directed to learning more about the virus and using this information to develop resistant corn hybrid varieties. As a result of these efforts, MDMV has been brought under a reasonable degree of control.

Recent spread of a new strain of the virus, however, is causing some concern. Hence, a Southern regional research project on corn virus diseases has been developed, in which Ohio and Illinois are also contributing.

The significance of this cooperative research becomes apparent when one considers that maize dwarf mosaic virus was causing an annual $6 million loss in Ohio alone before resistant hybrids were developed.

One of the classics in the RRF program is a project known as S–1, Genetics and Cytology of Cotton, which, over a 23-year span, has perhaps paid more research dividends than any other regional project. It got underway at least a decade before basic research became popular.

At that time, 1947, a few geneticists, cotton breeders, and administrators argued that the pool of germ plasm in commercial cotton had become too narrow. They believed greater variability in genetic materials was urgently needed to improve the cotton plant. They won their plea, and S–1 research began.

Among the S–1 objectives was one on plant resistance to cotton insects and diseases. (Other objectives and their records of achievement are discussed elsewhere in this publication.) The results were most favorable. In screening new cotton types, breeders found several substances that affected boll weevil responses to its host. They also identified several biotypes of cotton that reduce oviposition (incidence of egg laying). Three plant traits were found to impart resistance to the bollworm and budworm. Most of these traits are being transferred into commercial type cottons.

Additional research under S–1 has led to development of new varieties with improved levels of resistance to nematodes, fusarium wilt, and bacterial blight.

Achievements in other crop protection research under the RRF program include:

- Improved corn borer control practices in the North Central States.
- Devised plans to predict potato leafhopper migration, thereby enabling growers to take timely control action.
- Developed a soybean variety resistant to nematodes.
- Demonstrated that forage grasses and legumes can be selected for resistance to grasshopper feeding.
- Developed alfalfa strains resistant to the spotted alfalfa aphid.
- Introduced and established a Hawaiian parasite to control Rhodes grass scale in Florida.
- Discovered the vector causing oak wilt disease.

Weeds

When weeds are allowed to grow unchecked in many crops, the competition can markedly depress yields. In modern agriculture, it would be impractical to try to control weeds entirely by hand pulling or cultivation—either because of the high costs or insufficient control. Thus it becomes a challenge to weed scientists to alter, interfere with, and regulate the growth of plants—to kill some and to spare others in the same environment according to economic purpose.

The greatest success in weed suppression has resulted from the physiological approach to improve the efficiency of chemical control measures. Much of the regional weed research has focused on (1) the influence of environmental and other factors on the effectiveness of herbicides, (2) the behavior of herbicides in plants and soils, (3) the ecology of crops and weeds as related to control methods, and (4) the response of plants and plant communities to sustained use of herbicides.

A regional project in the South brought almost revolutionary changes in cropping practices. Prior to 1960, Texas cotton growers had no effective herbicide. By 1970, more than 50 percent of the cotton acreage in that State was treated with herbicides—due in part to knowledge gleaned from the regional project.

In keeping with ecological concerns, scientists working on the Southern project refined herbicide rates, thus bringing savings to growers and less danger of pollution. They also proved that the commonly used herbicides, when applied at recommended rates, leave no phytotoxic residues after one year.

Working on a Western regional project, weed scientists at the Washington Agricultural Experiment Station learned that weeds—like insects—can develop a resistance to herbicides, although it may take longer. They believe resistance takes place at the cellular level and is related to nitrogen metabolism. To stave off resistance, they recommend pre-planting tillage and rotation of kinds of herbicides.

Much of our knowledge about the influence of the environment on plant response to herbicides has come from the Western regional project. Recently, the project was modified to study the response of plants to sustained use of herbicides. It seems reasonable to expect that these studies will give scientists a better understanding of total plant function and improve efficiency of herbicidal control.

Poultry and Livestock

An adequate and wholesome supply of animal proteins for U.S. consumers demands effective control of animal diseases, insects, and parasites. The RRF program has made worthy contributions to research aimed at holding down losses from these hazards.

Twenty-two years ago little was known about the nature or control of major respiratory poultry diseases plaguing the poultry industry. All four regions, therefore, started intensive research programs to try to bring these diseases under control. These programs gave top priority to (1) devising techniques to diagnose infections rapidly and accurately, (2) developing control agents and methods, and (3) determining how to immunize flocks.

The first achievement was to develop ways to distinguish one respiratory disease from another. From this came fluorescent antibody tagging of virus and tissue culture, which made diagnosis a rather routine matter for field workers. Later, immunizing agents were developed for use in vaccinating large numbers of birds. By the time these projects ended, poultrymen had safe, effec-

tive, easy-to-use vaccines available for fighting three of the crippling respiratory diseases.

Largely through regional cooperative research, poultrymen no longer face serious economic losses from avian respiratory diseases. This has been a major factor in the remarkable increase in efficiency of poultry production in the United States. Thus, the consumer's dollar buys more poultry meat today than in 1948. Furthermore, consumers have greater assurance of getting safe, wholesome poultry products.

Notable gains have been made in efforts to control livestock diseases and parasites—particularly those of significance to specific regions in the United States.

- From a North Central project has come much of the new knowledge about the causes of death losses in young pigs—principally in viral diseases, internal parasites, and nutrition-related disorders. A higher survival rate in new pig litters today brings economic benefits to both producers and consumers.
- Another North Central project removed some of the veil of mystery from shipping fever disease of cattle. Stress factors were shown to be one cause of the disease. Some of the sulfa-type drugs brought marked clinical improvement in affected calves.
- Brilliant research in the Northeast and Southern regions dramatically lowered the incidence of diseases affecting reproduction in cattle. Prior to this research, losses from one of these diseases—vibriosis—were estimated at more than $30 million annually. Cost of the research was a mere fraction of that amount.
- The same deadly disease in the Western region—vibriosis in sheep—now rarely plagues sheep producers in the West because of research successes in determining the mode of transmission and developing an effective vaccine.
- An intensive research program in the Western region—aided subsequently through educational efforts by Extension agents—has enabled producers to practically rid their cattle and sheep herds of nematode parasites.
- A recommendation for deferred castration and the addition of certain elements to the feed of cattle and sheep—a research achievement of a Western regional project—has markedly lowered the incidence of an affliction known as urinary calculi.

Environmental Hazards

Early efforts to hold down agricultural losses from diseases, insects, and weeds also reflected an acute awareness of the need to consider ecological aspects of fighting pests—despite the fact that the concept of a clean environment was rarely mentioned then.

RRF projects on the effects of pesticide residues in crops and soils got underway in the four regions in 1953. Early work dealt mostly with taking field samples, making bioassays, and studying the relative effect of pesticides on a wide variety of crops and soil types.

When growers started using the newer synthetic organic insecticides, the tempo of residue effect research rose sharply—chiefly because of the large number of new formulations, and because of their more persistent nature. Moreover, expensive equipment was needed and the research demanded the skills of well-trained scientists in several disciplines. The resources of RRF enabled experiment stations to meet these new needs.

One of the important accomplishments in

each region is a summary of the pesticides and crops on which residues were studied and the location of the research. In compiling this summary, States exchanged referee samples and jointly determined errors of field sampling and extraction. Standardizing the techniques allowed more confidence in the findings. One region made disappearance curves for insecticide residues on a number of crops. These curves relate dosage and time of application to residues and tolerance limits.

Getting useful information from residue research is not always a simple matter. The big problem is that some chemicals may interact with other chemicals when applied to the same crop. Thus, regional scientists have had to set up balance sheets showing what was applied, how rapidly it disappeared from the soil or the surface of the plant, what was absorbed, and what changes took place in the chemical until its total fate was determined. Actually, this is one of the main thrusts of present-day research. The goal has been to balance the advantages of a control effort against possible economic disadvantages.

How well has RRF research succeeded in reaching this goal? Despite increased use of pesticides in the past five years, residues have *not* increased correspondingly. There are a number of reasons for this. Growers now have a wider choice of specific-target pesticides, and—thanks to research—they know how to apply them more effectively.

Regional research has also tackled problems of environmental hazards affecting livestock and poultry. A North Central project, for example, developed criteria for evaluating environmental conditions of poultry. Among other findings, poultry scientists showed that type of housing—open vs. confinement—has little effect on basic physiological responses of laying hens—whereas insufficient feed and water, handling, and cold exposure do.

Many present-day poultry housing practices are based on findings of a Northeast regional project: windowless houses, controlled lighting and environment, wire cages with sloping floors, and litter moisture control.

Selective pesticides mean the difference between corn earworm-infested corn as shown here and the quality, insect-free product enjoyed by consumers.

Efficiency of Production

Producing an adequate supply of quality agricultural products at diminishing cost has always been a primary goal of U.S. agriculture. Expression of this goal has, in turn, always been sharply evident under the RRF program. The approach has been to improve efficiency through whatever means either biological potential or the ingenuity of science could offer.

In crops, this has been done by breeding improved varieties and by devising more efficient ways of producing and harvesting them.

In livestock and poultry, improved breeding practices, nutrition, and housing represent the major routes through which science and technology can contribute to the need for maintaining an adequate consumer supply of animal protein.

Crops

The rich history of the Southern regional project, Genetics and Cytology of Cotton (mentioned earlier under crop protection), reflects notable achievements in research on ways to improve the productive efficiency of cotton.

Geneticists and plant breeders first undertook a massive program to classify, screen, maintain, and catalog species. Then began an intensive effort to single out, combine, and utilize the best plant characteristics of economic value. This was a slow, painstaking process because each component had to be studied separately to assess its contribution to total variability. Then, too, geneticists had to reckon with one of the major barriers to cotton improvement—the difficulty of recovering desirable traits in first generation crosses.

Several generations of random intermating, however, effectively broke up linkage blocks and provided a broader array of combined genes for selecting desirable plant traits.

The pace of cotton genetics and cytological research stepped up markedly during the second decade of the S–1 program. As a result, 28 of the 32 currently recognized species of *Gossypium* cotton are available in culture.

Inheritance patterns of economically important cotton plant traits have been elucidated so that they can be utilized by breeders:

- Glandless strains are a source of cottonseed oil and meal that are practically free of the toxic substance, gossypol.
- Glabrous strains reduce the amount of trash

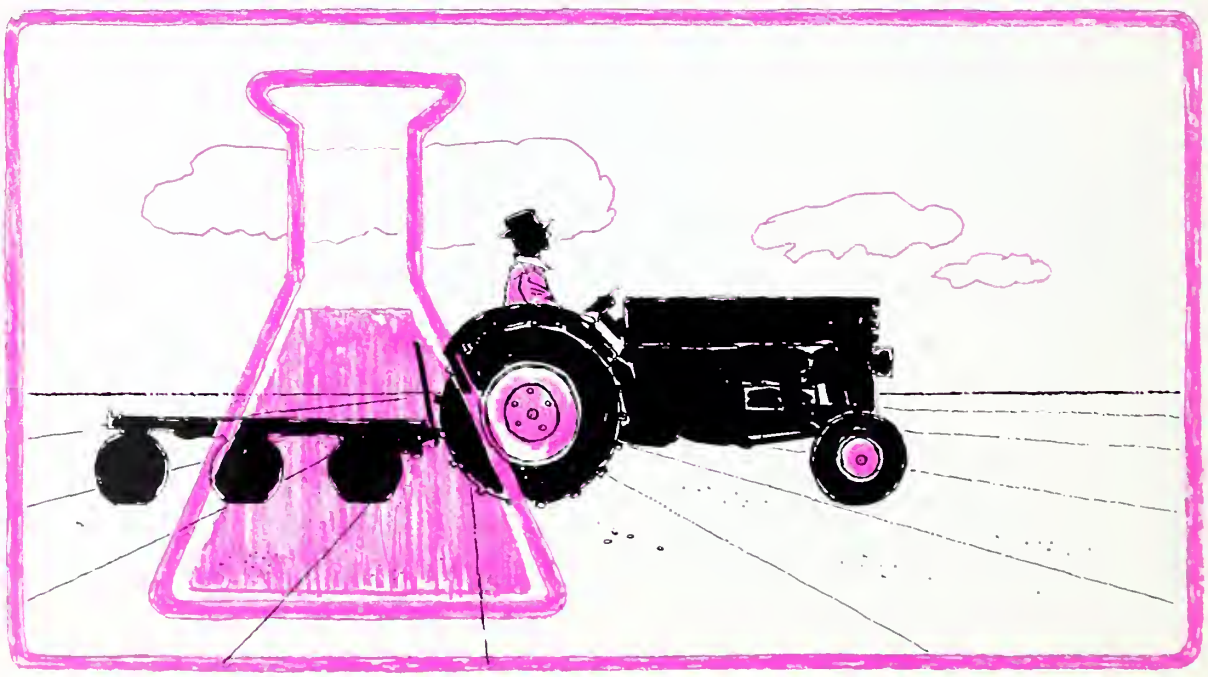
harvested by mechanical pickers.

- Glabrous and nectariless strains both have adverse effects on certain cotton insects.
- Plant selections from a pollen-irradiated variety of cotton yielded more lint, matured earlier, and had longer fiber than the original variety.
- Much progress has been made in developing superior hybrid types of cotton.
- Fiber research physicists have developed new instruments or modified existing ones to measure fiber length, strength, and other properties.

Prior to the RRF program, reforestation of ponderosa pine was largely a hit-or-miss affair. In the southwestern States, particularly, planting programs covering thousands of acres were often total failures. But since the completion of a Western Region project, successful regeneration of new ponderosa pine forests is now assured. Through this project, foresters now know the limiting effects of environment on tree development. Their recommendations on establishment and growth of both natural seedlings and planted stock have removed much of the margin for reforestation error. Thus, North America's 36 million acres of ponderosa pine can now continue to be maintained to supply our increasing demands for timber. This project is typical of the measure of success in other regional forestry research.

Studies on the management of perennial forage in the Northeast Region have enabled extension workers to recommend new methods for planting, maintaining, and rejuvenating pastures. Of greatest value, perhaps, was the research on alfalfa. Intensified cutting schedules practiced by farmers and increased incidence of alfalfa weevil damage have become lesser physiological hazards as a result of research findings.

All fruit trees and many woody ornamentals must be propagated by grafting the desired clones, or cuttings, onto either seedlings or vegetatively propagated rootstocks. The rootstock is the foundation of the plant and influences its size, shape, reproductive habit, and longevity. Thus, any new knowledge about scion-rootstock



relationships can contribute to the productive capacity and usefulness of plants. This was the general objective of a North Central project started in 1965. Few other RRF projects have yielded such a splendid record of achievement in such a short time and with only limited funding.

One of the striking developments from this project is the use of an intermediate dwarfing stem section between the seedling rootstock and the grafted chosen variety. Trees propagated this way are more uniform, more adaptable, and have improved characteristics. This new method has helped to make dwarf apple trees the "giants" of the fruit industry.

Because of this North Central project, recommendations on rootstocks for propagation and for the planting of trees have changed considerably. The outcome: more profitable orchards, improved ornamental tree plantings, and increased usefulness of tree populations.

The advantages of mechanical harvest of agricultural products are much more than just eliminating drudgery. The massive amounts of food and fiber needed to meet the needs of our growing population can be supplied only through the assistance of mechanization and its capacity for volume production. In recent years, mechanical harvesting has moved into vegetables, which formerly were mainly hand-harvested. A number of factors have forced this change.

- The farm labor supply is declining steadily, and the forecast calls for an even tighter labor market. If more improved harvest methods are not developed, some crops may even disappear from the market because of competition from those that can be mechanized.
- Fruit and vegetable growers no longer limit their marketing to surrounding communities. Centers of production now serve many areas of the country. Such mass production can only be possible through increased mechanization, which, in a way, helps to offset costs of storage and transportation.
- Consumer use of processed fruits and vegetables is rising rapidly. Mechanized harvest has helped to provide the high capacity required by processing plants.

Research on mechanization in the RRF program has concentrated mostly on the tough problems unique to a region: fruit and vegetable harvesting in the North Central Region, forage harvesting and processing in the Northeast, and mechanization of cotton in the South and West.

It would be difficult to assign credit for specific accomplishments in the mechanical harvest of fruits and vegetables in the RRF program. For one thing, most States producing sizeable quantities of these crops have also conducted research on an individual basis, and each effort has helped the other.

The implications and trends in mechanical harvesting indicate growers will continue to increase production in spite of increased wages, less labor, and the need for more skilled operators. The result: more economical operation of larger holdings with less manpower, yet more timely harvest of crops.

After World War II, interest in mechanizing cotton production literally exploded. Growers and scientists alike realized that drastic changes in growing practices would be necessary if the spindle-type picker were to be wholly successful. Consequently, two regional cotton mechanization projects were set up—one in the South in 1947, and, later, one in the Western States. These projects brought research expertise to bear on common problems with little or no duplication because of coordinated planning and free exchange of ideas and results. Research in industry also played a major role.

Among the specific new developments in the Southern project were: better tillage methods, the plateau planter, rotary hoe, low-pressure low-volume spray equipment, cotton topping, and selective type harvester. Records of the Western regional project show comparable gains. The outstanding overall achievement of mechanization has been the reduction of manpower needed to produce a bale of cotton—from 160 man-hours to as little as 15.

Livestock and Poultry

In striving for greater efficiency of livestock production, animal scientists in the Western Region have directed much of their attention to the problem of functional infertility—one of the

most difficult and costly in the industry.

The earliest phase of this research showed that nutrition is not a factor in fertility if rations meet regular requirements for growth and production. Guidelines were developed for selecting highly fertile bulls. When the semen from these bulls is deep frozen for use in artificial insemination, the influence of the bull as a cause of infertility drops.

The second phase attempted to define the physiological differences between normal and abnormal reproduction in cows. In these studies, animal scientists unearthed new knowledge about organ change and hormone metabolism of cows and promptly set out to try to synchronize estrus (the period of sexual heat) among the herd and reduce the interval of low fertility after calving. Although these goals have not yet been wholly attained, some authorities believe enough progress has been made so that cattle producers will soon have much greater control over the reproductive function of their herds.

The third and fourth phases of this project have concentrated on gaining a better understanding of hormone changes in cattle and sheep during the reproductive cycle. These studies, project leaders believe, will eventually enable livestock producers to not only control time of birth of calves and lambs, but also induce multiple births and—hopefully—control the ratio of male *vs.* female offspring.

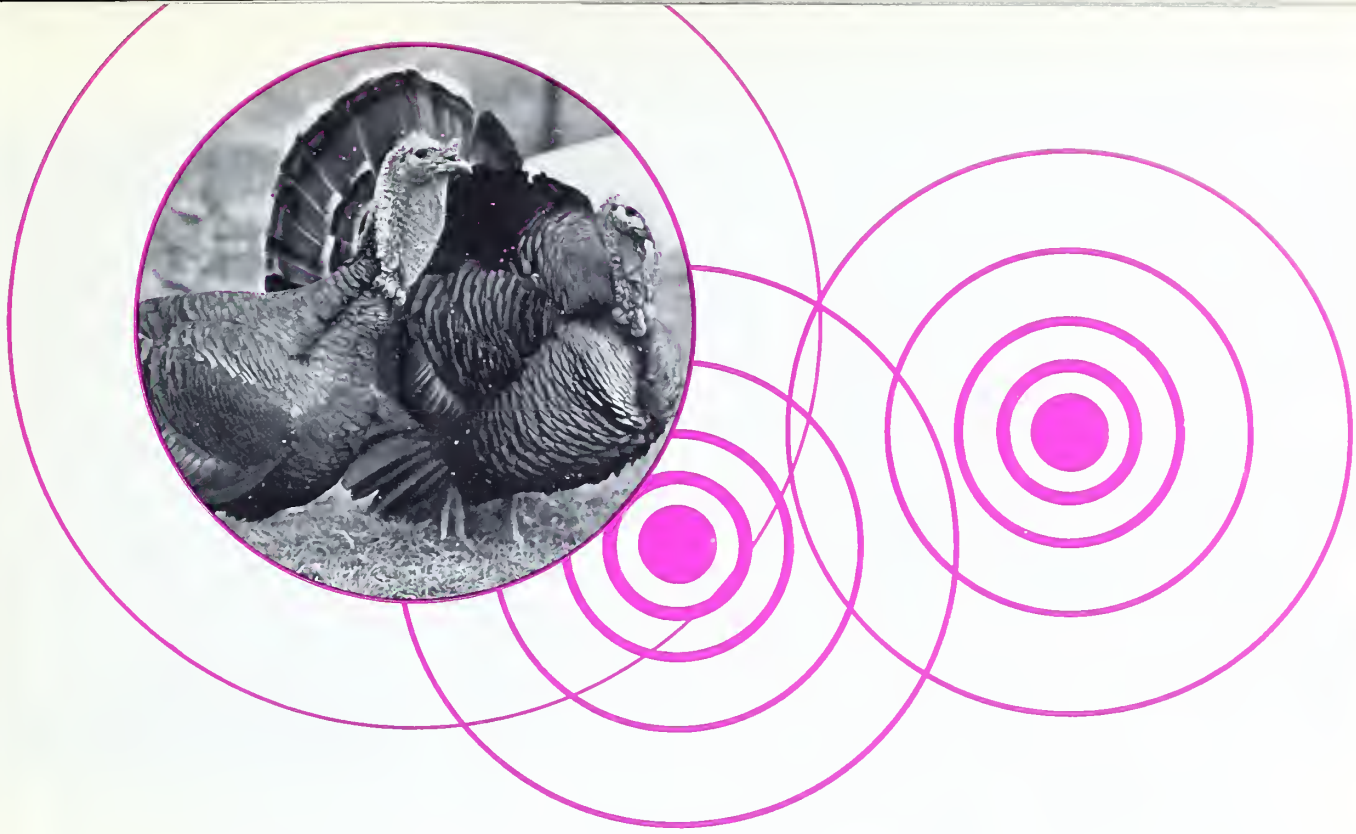
Poultry breeding projects in all four regions—coupled with the cooperative efforts of two regional poultry laboratories—are responsible in large part for the high state of efficient production in the poultry industry today. Much of this research was basic, but its usefulness was proven through application of the principles to breeding and to the production practices at the farm level. Few other RRF programs have had such a wide-sweeping effect on American agriculture.

Feeding and housing research under RRF has also left its mark on the degree of efficiency of livestock and poultry production. Here again, the total research contribution was increased by the synergistic effect of kindred activity by State and Federal agencies.

The range of RRF activity has been broad, as subject titles of some of the research publications will show: low temperature drying of shelled corn, pneumatic conveying of chopped forage, farm feed meters, vertical elevators, mechanical silage feeders, automatic vacuum release milking unit, automatic bunk feeding, paste feeding system for swine, and others.

In a way, agricultural engineers were fighting the image of the 2-story farm buildings and their attendant inefficiencies in housing and feeding farm animals. As a result, innovations such as loose housing, pipeline milking, large diameter silos, mechanical unloaders, and pole barns are commonplace on American dairy farms.

Because of Western regional research findings, reforestation of ponderosa pine has less margin for error.



Product Development and Quality Improvement

A generation or so ago farmers marketed whatever they produced without too much concern for what consumers wanted. Today, however, they cannot afford to disregard the consumer viewpoint if they want to retain the market. The consumer latitude of choice and purchasing power more or less dictate the need to focus on improved quality.

Regional research attempts to improve quality by starting with plants and animals having the built-in genetic ability to produce the desired attributes. Such an objective in agricultural research makes good sense for two reasons: It saves money and enables producers to market commodities more nearly suited to consumers' wants and needs.

The importance of regional activity in this area of research is borne out by its long history of growth and achievement. Chances are no other group of projects has a higher payoff per dollar of research investment. This is particularly true for crops.

New and Improved Crops

The concept for research on new and improved crops was already well established before the RRF program began. Agricultural scientists started looking for new and useful plant species as early as the 1850's. But it was not until the search became a cooperative regional effort that it received sustained support.

Foremost in the regional studies are four identical projects—one in each region—for introducing, testing, multiplying, and preserving potentially valuable plants for crop improvement and industrial use. Their objective: To help maintain agricultural productivity by supplying new germ plasm needed to meet the threat of disease, insects, drought, and other hazards.

Each region has a Regional Plant Introduction Station, supervised by a regional coordinator and a technical committee. By agreement with USDA's Agricultural Research Service, all stations operate under a system of priorities for the receipt, increase, and maintenance of new germ plasm—generally for the crops indigenous to the region.

Since 1949 germ plasm introduced from abroad and supplied to plant breeders has contributed to hundreds of new varieties of horticultural, field, and forage crops. As one regional coordinator put it, "We are the starting point

A female ash borer moth calls her mate by exuding a chemical attractant, pheromone. RRF entomologists are exploring the potential of sex pheromones for controlling populations of destructive pests.

Dwarf apple trees – vastly improved by R industry.

Development of disease-resistant corn varieties has enabled corn producers to avoid losses from the deadly maize dwarf mosaic virus disease. Containers show comparative yields of susceptible and disease-resistant varieties.

Mechanical harvest eliminates drudgery and helps meet the needs of g w populations. Regional research aided in developing this Concord r harvester, now used for 90 percent of our crop.

F research – have become the "giants" of the fruit

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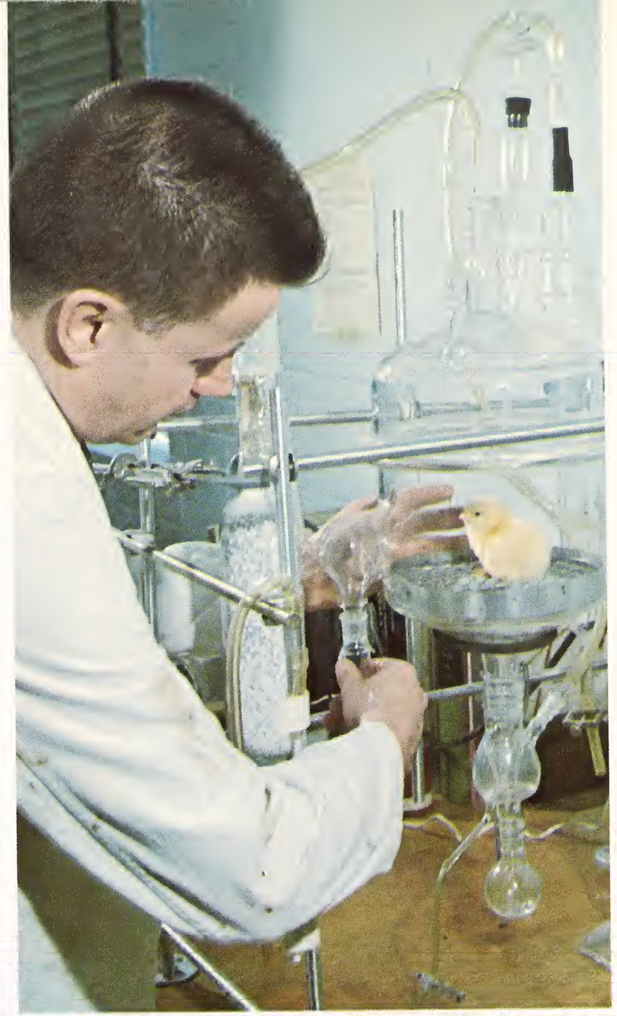

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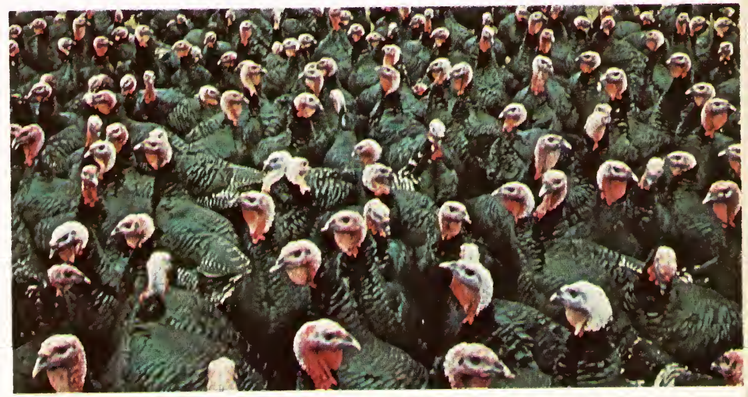


The saga of U.S. turkey breeding research closely parallels consumer preferences for type and size of bird.

to stately rows of mother trees—give a sense of order and meaning to agricultural research. At the isolation orchard, lying quiet and lonely between Rattlesnake Hills and the Yakima Ridge, trees grow and bear fruit without the constraints of either disease or insects—all of them evidence that the repository is a healthy and viable resource of the American fruit industry.

In the pathological research aspect of IR–2, a sort of breakthrough has been achieved by extensively modifying a technique called thermotherapy—holding young plants for 3 weeks in a 100° F. chamber for virus eradication. This treatment arrests the advance of virus from infected plant parts into new shoots from which healthy starts of many hitherto unknown healthy varieties have been obtained.

IR–2 is one of the happy success stories of regional research. The repository has achieved its main objective and now routinely distributes virus-free propagating materials to cooperators for use in research or for increase and release to industry.

New and Improved Animals and Animal Products

Research on the improvement of animals and animal products has been singularly adapted to regional research, because the problems are complex and place a high requirement on the research resources of individual States. The routes usually followed to achieve the goals have been through breeding. Just as with crops, this phase of the RRF program has placed more emphasis on the genetic approach.

From the earliest days of RRF activity, each region has vigorously sought to improve beef cattle by breeding procedures. Among the goals for all regions, the overriding one has been consumer acceptability of the product. At the same time, of course, benefits have come to producers in a variety of ways.

Results of these on-going projects have been documented in hundreds of publications—both popular and technical. Some highlights:

- The Southern Region project has been materially responsible for the expansion of beef cow numbers in the South—now more than 40 percent of all beef cows in the United States.
- Genetic effects of crossbreeding have increased efficiency of production approximately 25 percent.
- Acceptance of genetic control has led to widespread adoption of production testing programs.
- Research on inbred lines showed development of undesirable abnormalities that lower production.
- Dairy-beef crosses resulted in heavier weaning weights of calves because of the superior milk production of the dams.

Regional research on beef cattle breeding showed certain "in-house" advantages such as permitting evaluation of lines under different environmental conditions and more replications of individual experiments and, hence, more reliable data. Furthermore, this research has markedly influenced the decline of the heavy "Durham ox" type of beef animal once considered ideal, and, in turn, its replacement by a lighter weight, more efficient animal yielding more palatable cuts of meat.

Regional research has also studied carcass evaluation of beef as an aid to marketing a product that better meets consumer demands. These studies, conducted largely in the North Central Region, provided more rapid means of determining carcass composition and marketability. The research has also contributed much to the present USDA yield grade system.

A Northeast project on the genetic and environmental factors affecting composition of milk found that:

- Inheritance factors strongly influence the types of protein and other components in milk.
- More rapid gains in nonfat components of milk can be obtained by wider use of sires, through artificial insemination, that carry traits of above average percentages of solids-nonfat and protein.

In addition to the product improvement research on beef and dairy cattle, all four regions have also done similar studies on poultry. Results of this research have been incorporated into the commentary under Efficiency of Production.

Marketing Efficiency

A sizeable part of the fiscal and manpower resources of the RRF program has been consistently channeled into research aimed at improving marketing efficiency. Consumers have a stake in this kind of research because it leads to improved quality and lower cost of the products they buy.

The importance of marketing research takes on added meaning and significance in view of the increased marketing services demanded by consumers. These services—together with the cost of providing them—now take about 67 percent of the consumer's dollar spent for farm products.

Dairy Marketing

Cooperative research to maintain and expand markets for dairy products started early in all four regions of the RRF program. Over time, this research narrowed down to more specific priority problems such as changing market structures, patterns of use and technology, and milk processing and distribution systems.

Studies in the North Central States identified (a) the extent of milk distribution in paper containers and conditions affecting the movement, and (b) the impact of school milk programs. These studies—and others—led to needed adjustments in areas of low milk production, such as the Northern Great Plains, and to correcting surplus milk problems in fluid milk markets elsewhere.

Later studies in the North Central Region revealed useful data on dairy plant closings, dairy firm mergers, the changing structure of food retailing, and the emerging role of cooperatives. Critical analyses of the research findings helped producers and processors adjust to changing market conditions and changing technology.

Regional research in the South during the early 1950's examined alternative methods of paying farmers for their milk based on their contribution to supply in accordance with market needs. Economists studied various milk pricing plans and their effect on the seasonality of milk deliveries by farmers. They found that farmers were not receiving enough money for their milk. Farmers, in turn, worked to secure a payment method that included a classified pricing system. As a result, milk production in the South is more in line with market demands, production is more efficient, and pricing is more

equitable.

Regional dairy marketing research has been equally useful in the West and Northeast. The current thrust in all regions is expected to supply whatever information is needed to help maintain a progressive dairy industry.

Poultry Marketing

Poultry products are subjected to a variety of environmental conditions during processing, storage, and distribution. Knowledge of the effects of each environmental variable is essential for producing top quality products and for maintaining that quality throughout marketing channels.

Because of the widespread importance of the poultry industry in all regions of the United States, it was only natural that the problems should be studied in a unified and cooperatively planned effort. Accordingly, research projects were set up in all four regions at the start of the RRF program in 1947. At first, all of them adhered rather closely to marketing aspects *per se*. But researchers soon realized that, for poultry marketing research to be most effective, the projects should embrace much broader aspects and include studies on improving market acceptability and utilization.

Therefore, as programs were revised, technical committees assigned new, broader objectives to their projects. They realized that information gaps existed in such areas as the chemical, physical, nutritional, and functional attributes of eggs and poultry meats. Thus, the new mandate for poultry marketing research set the stage for one of the most productive programs ever carried out under the Regional Research Fund.

Studies in the North Central Region illustrate the quality and extent of achievements gained through poultry marketing research. This research represents a successful team effort by food scientists, poultry scientists, economists, and others. As problems were identified, each discipline cooperated in a common goal. Advances in quality improvement and market acceptability paralleled other developments in breeding, nutrition, and overall production.

Here are some of the significant contributions:

- Research on the causes of the high incidence of soiled eggs led to egg cleaning methods, use of sanitizers and germicides. Industry has accepted all the recommendations coming from this research.
- As a result of studies on the quality retention of eggs, most shell eggs for consumer use are now oil sprayed, either at the farm level or in grading stations.
- Background research on egg quality measurements contributed to the USDA egg quality grading system which measures quality of egg lots rather than single eggs.
- Research demonstrated variety strain differences in meat yield, quality, and consumer acceptance of final products. The result: improved meat birds.
- Studies on the microbial and chemical changes during processing and distribution of poultry and the application of findings to chilling procedures have improved shelf life of unfrozen poultry.
- Early research showed that removal of glucose from liquid egg before drying gave a sixfold increase in storage stability of the dried product. Also, development of an odorless, flavorless dried albumen resulted in an improved ingredient for angel food cake mixes.
- Regional research has strongly influenced

the type of turkey now raised—from small breeds to larger ones, because they can be produced more efficiently and can be marketed as turkey rolls and roasts. This new development was a direct result of regional findings on processing and cooking of turkey meat.

Research scientists associated with the present North Central project envision as many opportunities for new developments in poultry and poultry products as they have achieved in the past.

In other research activity, projects in all four regions resulted in the following representative accomplishments:

- Determined social, psychological, and economic factors that motivate people to use forest-oriented recreational activities in the Northeast. Aim of the project: To help people obtain maximum satisfaction from land and water resources.
- Helped owners of small woodlots improve their marketing position.
- Showed that processing and cooking will either eliminate or drastically reduce the residue levels of chlorinated hydrocarbon pesticides in certain foods.
- Determined the effects of cultural and handling practices on yield and quality of fresh market tomatoes.
- Devised ways to improve the merchandising and increase sales of potatoes, milk, and eggs in the Northeast.
- Developed standards for labor utilization and operating efficiency of slaughter plants.
- Devised useful non-chemical methods for eradicating insects from grain storage areas.
- Recommended more objective ways of determining hay grades, giving growers a better market advantage.
- Developed the "top turnout" method for making unbiased estimates of the value of wool, and provided western wool growers an equitable basis for making more profitable marketing decisions.
- Showed flower growers and shippers how to preserve product quality of flowers by using "moist-pack" containers.
- Set guidelines to help farmers and feedlot operators decide if an on-farm feed processing unit would be feasible.
- Analyzed consumer habits in buying fruits and vegetables and used this information to (a) assist retail store owners meet consumer needs and (b) show consumers how to buy these products more wisely.
- Determined consumer responses to food promotion and educational programs, thereby pointing up shortcomings in consumer nutrition knowledge.
- Measured elasticity of demand of selected citrus fruits at the retail and farm levels to aid growers in operating their business more efficiently.
- Compiled data that enabled extension agents to show growers and ginners how to improve the competitive position of cotton.
- Determined economy of scale guidelines for broiler producers and processors.
- Analyzed the structure of the textile industry, thereby enabling cotton growers to better meet industry needs for specific qualities of cotton.

Consumer Health and Nutrition

Early planners of RRF projects in 1947 observed that, although the life span of Americans had increased sharply within the past century, the period of effectiveness within that life span had not increased correspondingly. Could the problem be a lack of the right foods? Did our diets lack sufficient vitamins and essential minerals?

As a starter, about 4,000 people in each of three age groups—children, adolescents, and adults from 20 to past 80—were studied in 39 States. Generally, 7-day records of foods eaten were obtained and the nutrients were calculated from food composition tables. Adequacy of intake was evaluated by standards set up by the National Research Council.

Physical examinations and biochemical analyses of blood and urine samples were also used as criteria of nutritional status. Sometimes elaborate dental examinations and x-rays of bones and teeth were included in the records.

Results of the studies were compiled and interpreted so as to disclose differences, if any, in persons living in various regions, States, and local areas—and in persons of different ages and sex. General nutritional status appeared to be good, but certain deficiencies were clearly evident. Teen-age girls, for example, were not getting enough calcium, iron, thiamine, and ascorbic acid (vitamin C).

The impact of these early studies was long lasting. For example, research leaders of the Washington Agricultural Experiment Station report that today—20 years after collection of data in the Western regional segment—extension agents and public school nutrition teachers still use this information on the nutritional status and dietary patterns of teenagers in Washington.

A regional project in nutrition that represents the very flower of its type is S–28, Requirements and Utilization of Selected Nutrients in Preadolescent Children.

Studies under this Southern regional project have contributed more information to the understanding of nutrient needs of preadolescent children than any other research. Much of this information has been included in nutrition textbooks and will be the basis for nutrition recommendations for many years.

This project originated because nutritionists were concerned about the appalling lack of

information on the dietary needs of preadolescents. The central study began at the Virginia Agricultural Experiment Station in 1956. Researchers at eight other southern stations aided by analyzing samples and data and conducting related experiments.

The subjects—girls from 7 to 10 years old—lived under strictly controlled, but agreeable, conditions for a few weeks in the summer. Four such studies were conducted. All excreta were collected, urine was analyzed daily, and before and after measurements were taken of height, weight, blood, and body surface area. Although the major findings were in the area of protein, almost every nutrient was studied to some extent.

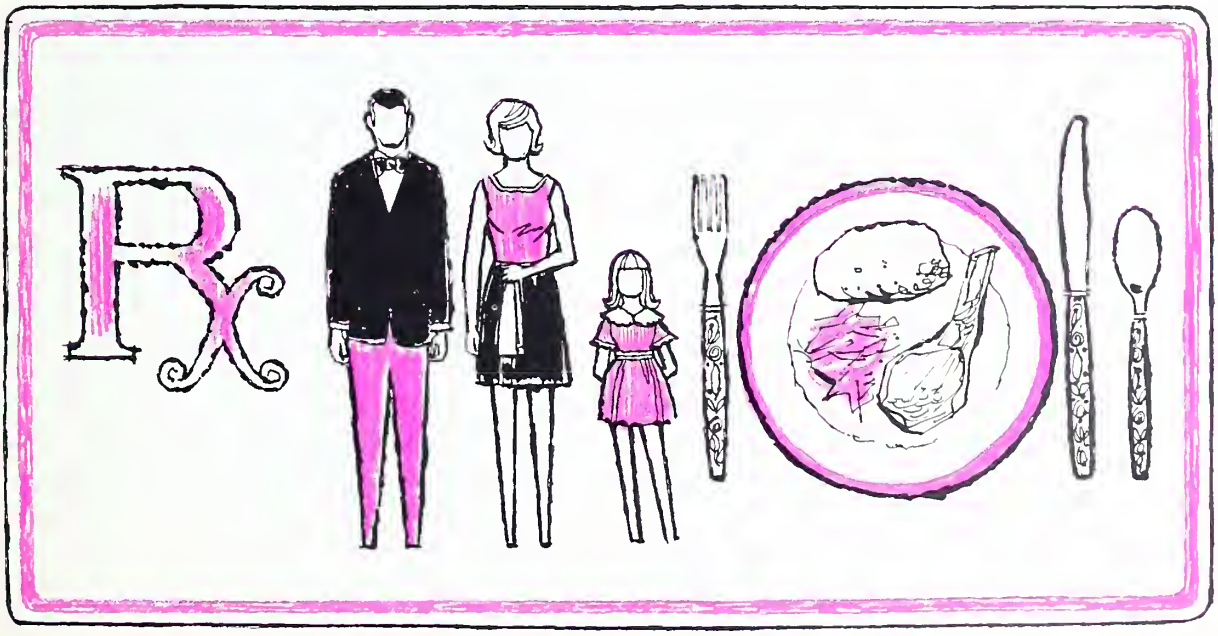
One of the facts pinned down by this research is that children of low-income families eat too little protein—probably because they receive insufficient meat, milk, or cheese. But since they do eat plenty of cereal grains, the obvious answer is to fortify cereal grains with protein—a practice which is becoming more prevalent today, both at the farm level and by food processors.

Another noteworthy outgrowth of S–28 research is the earnest counsel of project leaders that the allowances for protein for preadolescents then being recommended by the National Research Council and FAO ought to be higher than those for adults. NRC has since complied.

This study has also added new dimensions to past concepts about the iron needs of children. Results indicate that, under certain conditions, intakes of 9 or 10 milligrams of iron per day for 6- to-9-year old children may be adequate. But when children this age are fed diets composed primarily of plant products, even 12 milligrams a day may not be enough for proper nutrition.

In addition to yielding new and valuable information on the protein needs of children, S–28 has also contributed a wealth of knowledge on their requirements for amino acids, fats, vitamins, and minerals.

One of the pioneer research efforts with human subjects, the project—and its leaders—deserves much credit not only for overcoming the doubts of both the subjects and their parents, but also for using technology and psychological principles to assure a high degree of accuracy in the results. For example, in the early days of the study, children were taught



the importance of research in order to insure their wholehearted cooperation. This, project supervisors reported, was achieved; all the subjects displayed a sense of duty in their role of advancing science knowledge.

S–28 project leaders believe this project promoted the growth of nutrition competence in the South. Researchers had to pool their talents and, as a result, regional research and its deep-rooted philosophy of cooperative endeavor reached its peak in the South. Furthermore, an added advantage of regional research—as S–28 demonstrated—is that it helps to develop the competence of individuals who could not have advanced otherwise.

One of the happy spinoffs of S–28 has been the concept of "Community Mothercraft Centers"—a practical program for educating mothers in child feeding and hygiene in the emerging nations.

Since the termination of S–28 and its successor projects, nutrition research in the Southern region is continuing under new and revised program goals.

Capsule summaries of other nutrition projects:

- In 1956, food scientists of the North Central experiment stations directed their attention to some of the problems of quantity food preparation. Their goal was to devise ways to improve quality, palatability, and service of food prepared in institutions.

When this project terminated in 1964, more than 30 publications helpful to food service managers had been issued. Recommendations included tips on choice of meat cuts, cooking methods to retain palatability and reduce costs of both meats and vegetables, how to use nonfat dry milk, and planning more efficient use of equipment. These findings have been particularly useful in the school lunch program.

- Another North Central project showed that food processors should use caution in supplementing their products with amino acids (protein elements) because of the intricate balance needed among essential amino acids consumed if they are to be used effectively by the body.

- A North Central project on the diets of pre-school children revealed, among other things, a lack of parental understanding as to what good nutrition means—one of the most influential factors being a permissive attitude towards children's eating habits.

- Much of our present knowledge about the relationships between protein and other selected nutrients and their metabolism has come from a Northeast project involving nutritionists from 12 States. Findings were based on tests with both laboratory animals and human subjects. One significant finding: the most efficient use of protein comes only with a balanced diet of other nutrients.

- Western regional studies on the metabolism of lipids (fats) in human tissues have added much to our understanding of the way cholesterol and other fatty acids are stored and used in the body. The preliminary finding that cholesterol amounts and actions in women differ from those in men may lead to new concepts about the relation of cholesterol to cardiovascular problems.

Improved Levels of Living

An important component of the RRF program has been an effort to assist the more than 54 million rural Americans improve their level of living. Specifically, this research strives to (a) assist families to adjust more effectively to change, (b) improve their incomes, and (c) achieve socio-economic well-being.

Research on the social problems of rural America is particularly suited to the regional approach—not only because the issues tend to be region-wide, but also because the very complexity of these issues demands a multi-disciplinary effort and can therefore command the best talents from the States involved.

The importance of rural social research assumes even greater significance when one considers that the continued well-being of all America is deeply rooted to the quality of life in our non-urban sectors. As our population grows, the pressures on the land and on the people who nurture and raise its products will likewise grow. Regional research rises to these challenges. The examples cited here are typical of how these challenges are being met.

In 1952 the North Central Region turned its attention to the problem of young families getting established in farming, particularly those without substantial family assistance. At that time, public concern about a number of issues was beginning to rise: the fate of the family farm, the vulnerability of the beginning farmer, and the inequalities in distribution of farming opportunities.

The project ran for eight years. At the end of this period, social scientists working on the project could point to the following accomplishments:

- Detailed the process of getting started in farming in terms of initial capital, credit used, sources and kinds of credit, debt repayment rates, forms of tenure and sources of land, and kinds of family assistance.
- Developed improved estimates of numbers of farming opportunities available.
- Assembled information on land contracts as a low-equity land transfer device.
- Identified success and failure elements in selected cases of new farm enterprises.
- Documented interchange of land among farmers in a Nebraska county, thus revealing the competitive weakness of beginning farmers who had little family help.

All of the information gleaned from the study was made available to and used by extension workers and vocational agriculture administrators. In effect, the project helped ambitious farm youth make wise decisions about choice of vocation, timeliness of entry into farming or nonfarm work, avoiding capital and income losses because of inadequate financing or improper contracts, establishing credit, and making the best use of available family assistance.

Regional publications of the findings and recommendations were widely distributed and read. Although the social benefits are rather difficult to measure, project leaders conservatively estimate that if only 1 percent of farm boys in the region benefited to the extent of only $100 each by following project recommendations during the 1960's, the total benefit would be more than $2 million—far in excess of the research cost.

Meanwhile, a project with somewhat similar objectives attempted to give ambitious Southern youth help on starting a farm enterprise. This project, however, went one step further: It developed recommendations for established farmers who needed to adjust their operations to meet changing conditions. For example, researchers showed cotton farmers what opportunities were open to them under given levels of cotton allotment and prices. Extension specialists have used the data and methods from this study in training sessions and workshops to assist individual farmers in combining enterprises into a profitable endeavor.

Indications of the social problems in the rural South were revealed in the findings of a project on adjustments of families to changing conditons in low-income rural areas. As aids to solving these problems, project leaders reported the following:

- A profile and data bank defining typical situations is being used in follow-up studies by social workers.
- Aspirations of low-income families are unrealistically high in view of their limited opportunities for development.
- Action programs need to put more emphasis on the role of the homemaker in bringing about needed adjustments.

Findings of this study strongly imply that action agency programs within sub-regions need to be coordinated under a single agency because of the necessity for varied approaches due to cultural differences among the people.

Two Southern Region projects on the vocational goals of young people brought some new understanding to educators and social workers. Among other data, these studies revealed that (a) level of living strongly influences educational and vocational aspirations of youth, and (b) upgrading these aspirations—or even adequately measuring them—requires close attention to self concepts.

Although this research focused primarily on rural youth, urban youth were also studied in one phase of the investigations. Social scientists were attempting to understand the milieu of today's youth and its relation to their goals in life. This they did. But, more important, the studies pointed up a pressing need for more

Several regional research projects dealt with the goals and aspirations that young farm families have for their children.

Pressures on rural people and the land grow as population increases and urbanites seek new outlets and activities.

vocational guidance in schools and better parent-child communication on plans for the child's future. All of the findings are now available to the appropriate educators and will undoubtedly help guidance counselors working with ninth and tenth grade students do a more thorough job.

What proved to be a far-reaching and productive research program on rural housing in the United States was authorized by the Congress in 1946 and implemented soon thereafter under the Regional Research Fund. It sought to achieve, among other things, more efficient and satisfactory use of farm buildings and farm homes. All four regions participated.

Undoubtedly the most important accomplishment under these projects was the development and publishing of planning guides for rural homes. These guides covered space standards and facility designs for all aspects of physical facilities essential to a home. Included were requirements for the handicapped, the aged, and children.

Other separate studies yielded recommendations on ideal building sites, foundations, finishing materials, and heating requirements. Some exploratory work was also done on solar heating.

Results of all these studies are being incorporated into plans prepared by the U.S. Department of Agriculture for the regional plan exchanges which are available to all citizens through State offices. Information from a widely distributed Western Region bulletin, "Space Standards for House Planners," was included in the architect's "bible," *Architectural Graphics, Standards*—also is serving as training aids in architectural schools.

Other regional research related to improved levels of living tackled such problems as financial security, child rearing, social behavior, and housing for the elderly. Meanwhile, as the list of current projects in the Appendix shows, emphasis is increasing on a wide range of new problems: employment opportunities for disadvantaged people, resource potentials of rural youth, paths out of poverty, land use planning, and others.

Community Services and Environmental Improvement

This final category of research under the Regional Research Fund programs combines two areas of activity which at first glance may seem to be dissimilar—community services and environmental improvement. Yet the need for research in both of them is related more or less to the rapid changes brought on by new technology and the problems left in its wake.

Community Services

Changes on farms affect rural communities. Whether the change is economic, social, or physical, imbalances are set in motion and this means problems.

To a sociologist, some of these problems are merely symptoms of a larger problem: inadequate health and educational facilities, declining employment, undesirable demographic trends, and the like. But whether we regard them as individual problems or as symptoms of something more insidious, the fact remains that a great many rural communities lack the attributes needed to keep them viable and attractive places to live, work, and play.

The RRF program has recognized its obligation to use its resources to identify shortcomings in community services, and, hopefully, to try to effect changes.

How do changes in the social structure affect a community? In what ways are the leadership and decision making units reacting to these changes? What new problems do small communities—and families—face when industry comes in?

These were some of the issues the North Central Region investigated during the 1960's—the decade marked by a growing awareness of the significance of rural development. At that point in time, the most pressing need was to identify and analyze the changes in rural communities—a natural prelude, of course, to doing something about the problems themselves. In their study, North Central researchers learned that:

- Small towns near metropolitan centers grow less rapidly than central cities or the open country in metropolitan areas.
- To a large degree, small towns share a fate common with the larger area community in which they are situated. Nearness to large growth centers had a positive effect on population

growth.

- Declining villages invariably have a higher percentage of older persons than growing communities.
- A growing disparity was found between rural and urban areas in the availability of professional health care.
- New industrial employment opportunities had a striking impact on the educational and vocational aspirations of youth.

Similar research began in the Northeast Region in 1955. Its purpose was to study and analyze the effects of urban expansion on the agriculture of the region. By the time the project terminated in 1964, well over 100 publications had documented the findings. A random topic selection will indicate the broad scope of these investigations: residential mobility, the rural-urban fringe, income structure, the changing society, trends in human resources, rural underemployment.

A point of emphasis here: These early studies of rural community social problems were logical forerunners of today's heightened interest in rural development in the RRF program. Both Federal and State research leaders realize that rural America today is a frontier badly out of balance and urgently needs coordinated planning and development. Evidence of this awareness shows up in the number of new rural development-related projects now active.

Environmental Improvement

Another problem brought on by changes in technology is a decline in the quality of our physical environment. In some instances, technology has led to processes of concentration that exceed acceptable tolerance limits and impair the quality of our ecosystem—and thus the quality of our lives.

Agriculture is involved in two ways—the pollution which its systems create, and the outside pollution that adversely affects agricultural products. Two examples are cited:

- One of the first attempts to apply research expertise to the problem of animal waste management began in the North Central Region in 1963. At that time, although there was little public concern about this matter, research leaders noted the growing concentration of livestock and poultry production and its accompanying problem of what to do with the mountains of waste.

During the decade this project has been active, it produced more innovations in animal waste treatment equipment than any other single research effort. Cage rotors for oxidation ditches and poultry manure hydrators—both a product of North Central research—are now being manufactured commercially.

New knowledge on the properties and characteristics of animal waste has directly influenced legislative action in several States to prevent runoff from feedlots.

Two wrap-up publications—one in 1969 and another in 1971—gave producers complete details on the design, operation, and working principles of the newest systems, including aerated and anaerobic lagoons, reflushing of treated water, refeeding of high protein solids, composting, incinerating, and irrigation or plow-down of surplus liquids and solids.

This North Central project is another outstanding example of the synergistic effect on regional research. Scores of individual State projects and a number of national symposia were a natural outgrowth of this early research. Similar studies have since been set up in other regions.

- The Northeast Region pioneered in regional effort to collect air pollution data outside of urban areas. This project also was the first attempt to standardize cultural practices for growing bio-indicators as well as standardizing monitoring instruments to measure the vagaries of the oxidant problem.

Data from a 2-year continuous monitoring program showed that (a) there is a relationship between photochemical pollution/auto exhausts and agricultural damage to crops, and (b) photochemical pollutants are the principal pollutants of agricultural significance.

These Northeast studies also showed that higher levels of oxidants appear during weekends in the Northeast, and particularly between sunset and midnight. This finding suggested that our understanding of ozone as an unstable chemical was incomplete, because suffi-

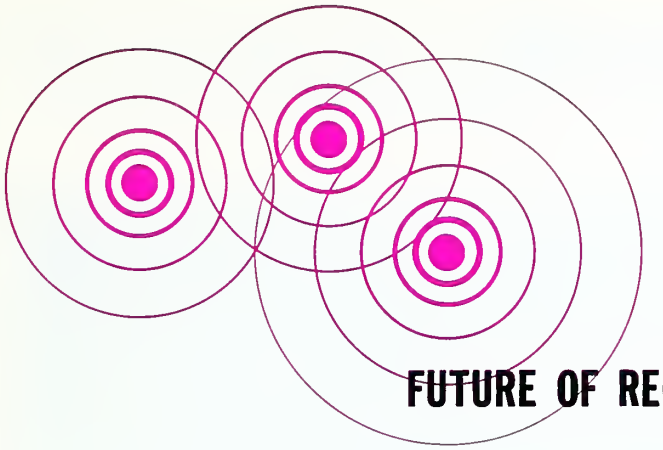
cient amounts of it are apparently produced at some distance from the point of night measurement and persist in the air—or, oxidants other than ozone are contributing to the high evening levels.

A second major accomplishment of the Northeast project was the discovery that tobacco is an ideal biological indicator of oxidants. Its use has confirmed the widespread incidence of the photochemical pollution problem. But even more significant, use of tobacco as a bio-indicator is a boon to limited budgets since electrochemical monitoring equipment is quite expensive.

Research leaders in the Northeast Region have developed a slide bank of color photos that enable investigators to distinguish between air pollution damage and mimicking symptoms. Copies of this slide collection are available for purchase and it is constantly being updated.

As one might expect, the tempo of research activity on environmental matters has quickened considerably in the 1970's. The list of current projects in the Appendix shows more than a score of ecology-related studies now in progress. One of the most ambitious and all-encompassing ones is titled, "Clean West: A systematic analysis of the economic and social implications of environmental problems."

In some respects, "Clean West" typifies a new trend in environmental research because it recognizes both the trade-offs and the sacrifices that must be made by society and technology in achieving a desirable ecological balance. Evidence of this theme, however, shows up in other regional projects, and clearly manifests one tenet of the philosophy of regional research—flexibility to allow reasonable shifts of emphasis as the needs demand.



FUTURE OF REGIONAL RESEARCH

The forces of change and the anticipated heavier demands on agricultural science and technology in the future will undoubtedly require regional research to broaden its dimensions to embrace new problem areas and expand its activities in others.

Some signs are already evident as to the nature of these opportunities and the degree of challenge they offer to participating RRF scientists.

- One of the high priority items is the need to learn how to make rural America a better place in which to live and work. As stated earlier in this publication, rural America is a frontier badly out of balance. The RRF program commands the facilities and resources to provide, through research, the basis for intelligent decision-making in planning and action programs.

The machinery and framework for the necessary multidisciplinary research has already been set up. What is needed now are some hard answers that will help to correct the imbalances and upgrade the quality of life in rural America.

- Of equal priority is the urgent necessity to raise the level of living of farmers to match that of other Americans—not only from the standpoint of average income, but also in areas of cultural and social amenities. Past regional research has accurately identified the shortcomings; further opportunity exists in using research to find ways to remedy the inequities.
- The RRF program might well use its resources to improve the interactions of the agricultural segment with the rest of society. Is the farmer an adversary or a friend of the consumer? What is the basis for the lingering misunderstanding about farmers? Regional research is well-suited to devise ways for changing any existing false impressions.
- In the rush of scientists and their institutions to place more emphasis on people-related problems, regional research still faces a continuing challenge to improve the production efficiency of American agriculture to insure a bountiful supply of food for domestic needs and sales overseas. Today, public concern over meat prices and the sensitivity of wheat and flour prices to foreign purchases show the continuing need to maintain research on efficiency of production, marketing, and distribution.

State and Federal research administrators have not been unmindful of the more complex problems and challenges of the future under the RRF mandate. To that end, therefore, the Agricultural Research Policy Advisory Committee in 1971 took action that promises to bring a new concept to regional and national research planning. Under this plan, research organizations are more likely to have better representation for coordinating and implementing regional studies. New regional planning committees for each of the four regions are expected to afford greater latitude in setting up regional research programs according to area needs. These committees will identify problems that must be attacked cooperatively in several States and those that can be solved more effectively at one location.

The rich history of the RRF program provides no guarantee, of course, that the second quarter-century will be equally as viable and productive as the first. On the other hand, past patterns of success may very well serve as incentives for future scientists as they attempt to surmount newer, more difficult challenges.

* * *

A typical example of results from cooperative regional research—short-strawed wheat adaptable to dryland farming and efficient machinery to harvest it.

APPENDIX

Regional Research Projects Active During Fiscal Year 1972

NORTH CENTRAL REGION

NCM–41 Market quality in wheat.
NCM–45 Factors affecting post-harvest market quality of processed potatoes.
NCM–46 Improved processing and utilization of poultry.
NC–1 Improvement of beef cattle through breeding methods.
NC–2 Improving dairy cattle through breeding with special emphasis on selection.
NC–7 New plants—the introduction, multiplication, preservation, and evaluation of new plants for industrial and agricultural utilization.
NC–62 Prevention and control of enteric diseases of swine.
NC–83 Seed production of breeding lines of insect pollinated legumes.
NC–89 Nature and utilization of genetic variation influencing economic traits in poultry.
NC–90 Factors affecting patterns of living in disadvantaged families.
NC–91 The effect of composition, distribution, and quantity of lipids on meat quality.
NC–92 Supply of and demand for public forest recreation in the North Central region.
NC–93 Animal waste management with pollution control.
NC–94 The climatic resources of the North Central region.
NC–95 Nutritional interrelationships in lipid metabolism.
NC–96 Environmental implications of pesticide usages.
NC–97 The relation of population to social change in the North Central region.
NC–98 Nutrient enrichment of waters by soils and sediments.
NC–99 Forest tree improvement through selection and breeding—Phase III.
NC–100 RRF administration, planning and coordination.
NC–101 Alternative solutions to new problems of dairy marketing cooperatives.
NC–102 The economics of institutional arrangements for viable rural communities in the Great Plains.
NC–103 Genetic improvement of efficiency in the production of quality pork.
NC–104 Systems analysis of the economics of grain marketing.
NC–105 Studies of the European corn borer—Feasibility of genetic manipulation to control the species.
NC–106 Alternative systems of vertical coordination in producing and marketing feeder cattle.
NC–107 Bovine respiratory diseases.
NC–108 Changes in food practices for better nutrition.
NC–109 Soil landscape characteristics affecting land-use planning and rural development.
NC–110 North Central regional center for rural development.
NC–111 Increased efficiency of lamb production.
NC–112 Impact of changing transportation systems on local grain and farm supply marketing firms.
NC–113 Endocrine imbalances during abnormal reproduction in cows.
NC–114 Forage production and utilization systems as a base for livestock production.
NC–115 Nutrition of high producing dairy cows.
NC–116 Avian respiratory disease control for consumer protection and market quality.
NC–117 Disorders in bulls related to aging and mineral metabolism.
NC–118 Utilization and disposal of municipal, industrial, and agricultural processing wastes on land.
NC–119 Improving large dairy herd management practices.

NORTHEASTERN REGION

NEM–22 Development of rapid methods of characterizing varieties to improve seed marketing.
NEM–27 Post-harvest physiology of pomological fruits: handling, storage, and utilization problems in the marketing channels.
NEM–30 Quality maintenance, measurement, and control in the marketing of vegetables, including potatoes.
NEM–33 Control of pests on perishable food commodities in marketing channels.
NEM–37 The impact of new production, harvesting, and procurement methods on the market structures of the fishing industry in the Northeast.
NEM–40 Impacts of regulations affecting competition industry organization and practice on the performance of the fluid milk industry.
NEM–41 Competitive position of the Northeast in marketing fruits and vegetables.
NEM–42 Economic analysis of the campground market in the Northeast.
NE–9 Discovery and preservation of valuable plant germ plasm.
NE–14 Virus and mycoplasma diseases and their control in deciduous tree fruits.
NE–24 The nutritive evaluation of forages.
NE–25 Pathology of wilt diseases of trees.
NE–27 Genetic adaptability of trees to forest environments.

NE–36 Pesticide residues in or on raw agricultural commodities.
NE–39 Factors affecting the accumulation of nitrates in soils, water, and plants.
NE–42 Ecological studies of certain weeds in the northeastern United States.
NE–44 Principles of mechanical harvesting of fruits and vegetables.
NE–47 Consequences of changing social organization in the Northeast.
NE–48 The dynamics and energetics of the soil-plant-atmosphere continuum (SPAC).
NE–49 The control of bird depredation.
NE–53 Degradation of agricultural pesticides in biological systems.
NE–54 Improvement of efficiency in harvesting apples.
NE–55 The ecology of selected submersed aquatic weeds.
NE–57 Breeding and evaluation of Kentucky bluegrass for turf.
NE–58 An economic and sociological study of agricultural labor in the northeast States.
NE–59 Regional research coordination, Northeastern Region.
NE–60 Genetic bases for resistance to the avian leukosis complex.
NE–61 Physiological responses of chickens to varying environments.
NE–62 Relationships between genetic markers and performance in dairy cattle.
NE–63 Disposal and utilization of dairy and poultry manures by land application.
NE–64 Biology of the plant-parasitic nematode, *Pratylenchus penetrans*.
NE–65 Economic analysis of environmental quality effects associated with seasonal homes.
NE–66 Genetics and physiology of sweet corn quality and biological efficiency.
NE–68 Paths out of poverty.
NE–69 Atmospheric influences on ecosystems and satellite sensing.
NE–70 Engineering systems for forage crop production and use.
NE–71 Infectious diseases affecting reproduction in dairy cattle.
NE–72 Control of reproduction in the bovine female.
NE–73 Nutrition improvement in the Northeast Region.
NE–74 Breeding of improved varieties of forage species adapted to the Northeast.
NE–75 Breeding for improved forage quality.
NE–76 Techniques for eradicating infectious diseases of poultry.
NE–77 Community services for nonmetropolitan people in the Northeast.
NE–78 Natural resource policies and planning for rural development.
NE–79 Consumer, market, and laboratory studies of flame-resistant textile items.
NE–80 Processes of rural economic change in the Northeast.
NE–81 Economic analysis of the impact of pollution control on marketing poultry and eggs in the Northeast.
NE–82 The influence of air pollution on plant productivity in the Northeast.
NE–83 Improving the assurance of quality and safety of consumer's food.
NE–84 Behavior and interrelationships of gypsy moth, parasites, and predators.

SOUTHERN REGION

SM–40 Market organization, power, and policies and programs in the dairy industry.
SM–41 Economic evaluation of alternative forms of vertical coordination in the livestock-meat industry.
SM–42 Predicted effects of selected policy and technology changes on the grain marketing system.
SM–43 Factors responsible for tenderness variations in meat.
SM–44 Factors affecting utilization and expansion potential for ornamental plants and turf.
SM–45 Spatial and temporal aspects of demand for food products.
SM–46 Systems analysis of the vegetable subsector of the food industry of the South.
S–9 New plants: Their introduction, multiplication, evaluation, and preservation.
S–10 Breeding methods for beef cattle in the Southern Region.
S–23 Genetic improvement of forest trees in the South.
S–45 Relationship between properties for southern forages and animal response.
S–49 Genetic methods of improving dairy cattle for the South.
S–53 Factors affecting water yields from small watersheds and shallow-ground aquifers.
S–59 Distribution, abundance, and control of *Heliothis* species in cotton and other host plants.
S–62 Inactivation and loss of pesticides from soil.
S–63 Influences on occupational goals of young people from three sub-cultures in the South.
S–65 Regional research coordination, Southern Region.
S–66 Physical, social, and economic aspects of functional housing for low-income families.
S–67 Evaluation of the beef production industry in the South.
S–68 Environment influencing genetic variability and evaluation of poultry populations.
S–69 Engineering systems for cotton production.
S–70 Viruses and mycoplasma-like organisms (MPLO) causing diseases of corn.
S–71 Regional income and employment effects of investments in natural resources.
S–72 Biological determination of performance for planting-seed.
S–73 Pesticide residues in agricultural commodities and environments.

S–74 Biology and control of arthropods on soybeans.
S–75 Biology and integrated control of the greenbug on sorghums and small grains.
S–76 Nature and extent of variation in root-knot and cyst nematodes.
S–77 Genetics and cytology of cotton—II.
S–78 Herbicide movement from application sites and effects on nontarget areas.
S–79 Rural development and the quality of life in the rural South.
S–80 Diagnosis and correction of zinc problems in corn and rice production.
S–81 Development of human resource potentials of rural youth in the South and their patterns of mobility.
S–82 Fertilizers and organic wastes applied to soils in relation to environmental quality.
S–83 Catfish breeding, production, and marketing.
S–84 Physiographic classification of southern forest lands.
S–85 Peanut variety and quality evaluation.
S–86 Performance of selected fabrics treated with flame-retardant finishes.
S–87 Patterns of food intake and nutritional health of girls.
S–88 Bionomics and control of the pecan weevil.
S–89 Animal waste treatment and recycling systems.
S–90 Rhizosphere ecology as related to plant health and vigor.

WESTERN REGION

WM–61 Agricultural factor markets and buyer-seller procurement strategies.
WM–62 Technological and structural changes in the marketing of beef.
W–6 Introduction, multiplication, maintenance, and evaluation of plant germ plasm.
W–45 Residues of selected pesticides—their nature, distribution, and persistence in plants, animals, and the physical environment.
W–46 Improving productivity of livestock under environmental stresses.
W–51 Dynamics of flow into drainage facilities.
W–56 The interrelation of nematodes and other pathogens in plant disease complexes.
W–57 Interrelationships of amino acids and vitamin utilization.
W–61 Development of selection criteria for the genetic improvement of carcass merit of sheep.
W–64 Characterization, ecology, and control of fruit tree viruses and virus diseases.
W–67 Quantification of water-soil-plant relations for efficient water use.
W–68 Measurement, prediction, and control of soil water movement in arid and semi-arid soils.
W–82 Pesticide mobility and degradation in soil-water systems.
W–84 Environmental improvement through biological control and pest management.
W–102 Biological methods of control for internal parasites of livestock.
W–104 Economic growth of the agricultural firm.
W–106 Regional research coordination, Western Region.
W–107 Management of salt load in irrigation agriculture.
W–108 Response of plants and plant communities to sustained use of herbicides.
W–109 Codling moth population management in the orchard ecosystem.
W–110 Relationships between root pathogens, their hosts, and attack by bark beetles.
W–111 Nitrogen in the environment.
W–112 Reproductive performance in cattle and sheep.
W–113 Improvement of employment opportunities and earnings for disadvantaged people in nonmetropolitan areas.
W–114 Institutional structures for improving rural community services.
W–115 Western Region area development research center.
W–116 Nutrition and food acceptance as related to selected environmental factors.
W–117 Structural changes in agricultural industries: Causes and impacts.
W–118 Economic and social significance of human migration for the Western Region.
W–119 Evaluation of alternative land uses on forest, range, and other wildlands.
W–120 Economic and social impact of adjustment in use of chemicals in agriculture.
W–121 Clean West: A systematic analysis of the economic and social implications of environmental problems.
W–122 Discovery and control of natural toxicants in the food chain.
W–123 Evaluating management of predators in relation to domestic animals.
W–124 Soil as a waste treatment system.
W–125 Soil interpretations and socio-economic criteria for land-use planning.
W–126 Physiological criteria for forage, range, and pasture plant breeding.

INTERREGIONAL PROJECTS

IR–1 Introduction, preservation, distribution, and evaluation of *Solanum* species.
IR–2 Obtaining and preserving virus-free deciduous fruit tree clones.
IR–4 Evaluation of current data and needed research to determine tolerance limits of chemicals for minor uses on agricultural products.

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